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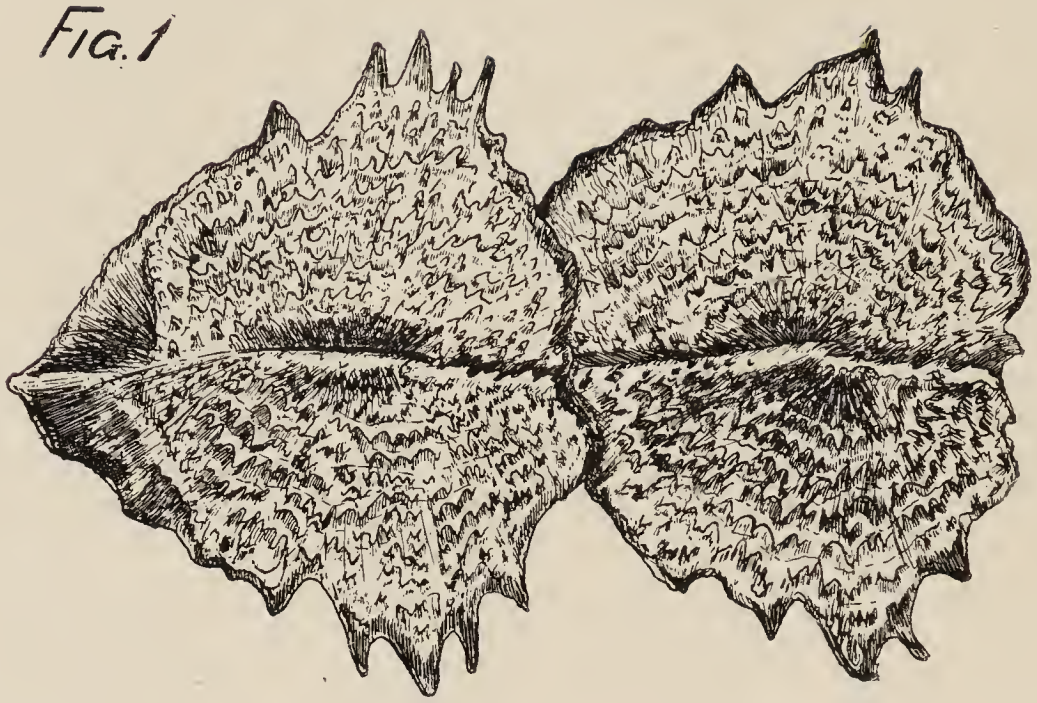

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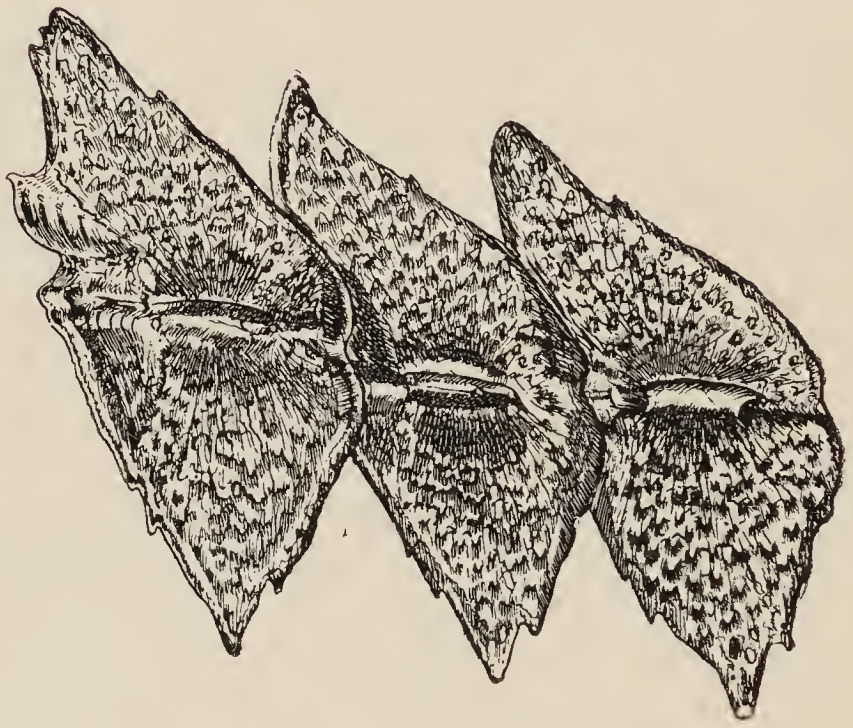

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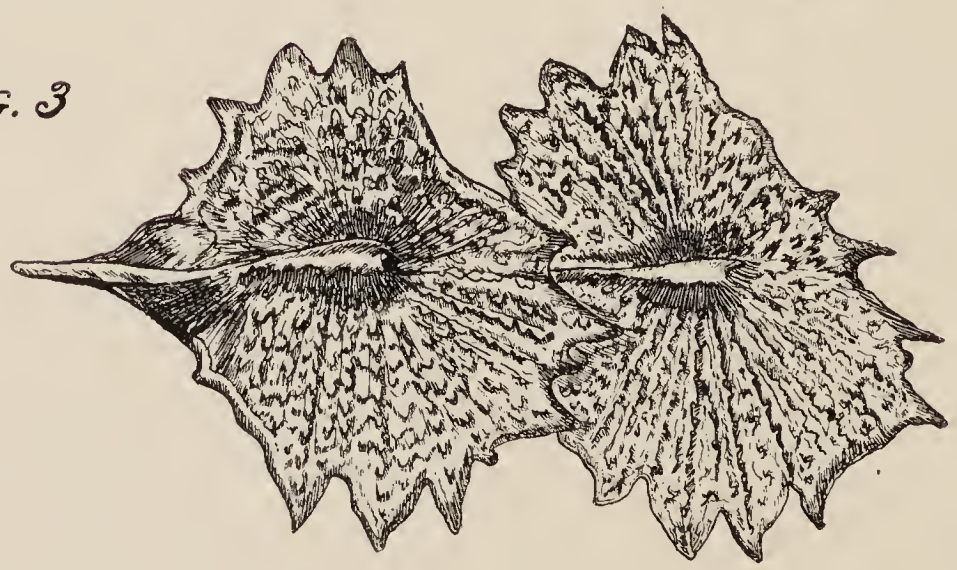

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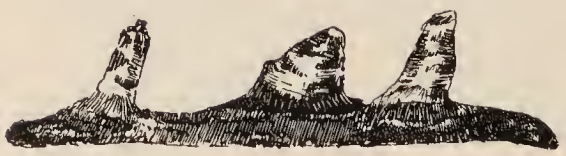
FIG. 4

FIG. 5



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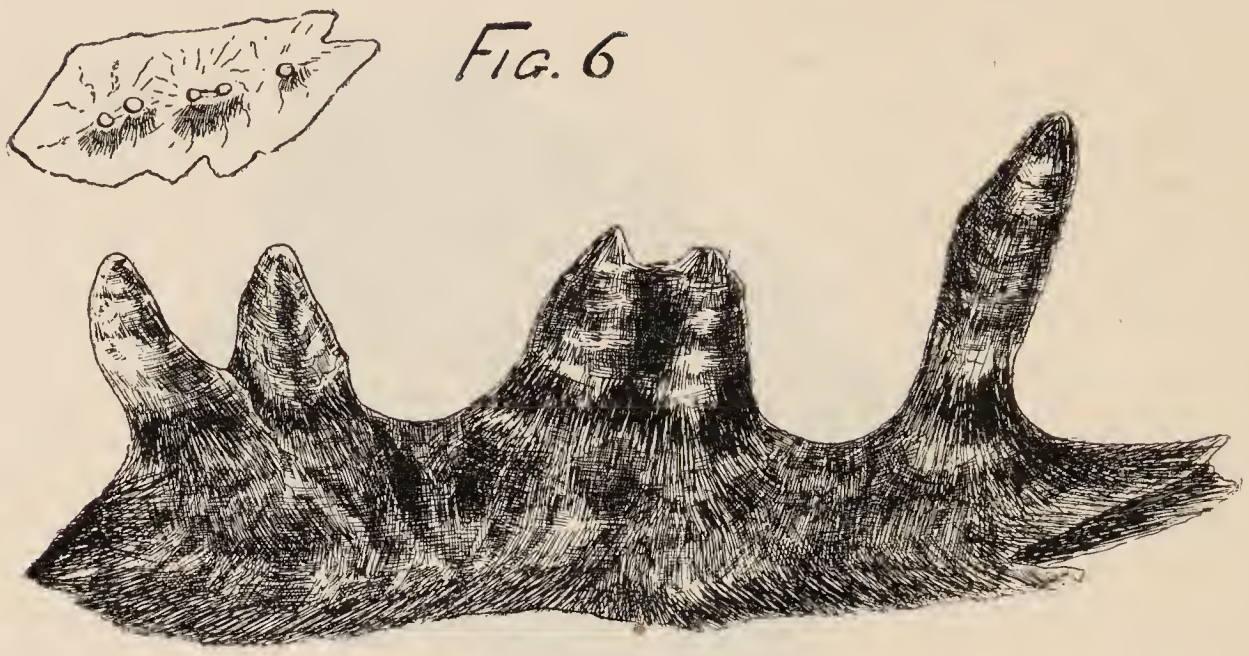

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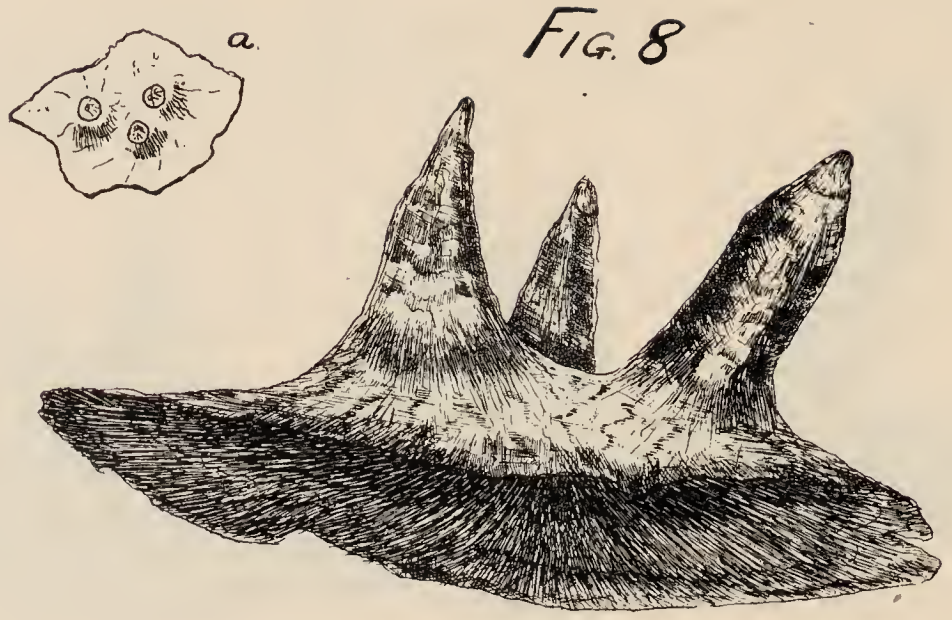

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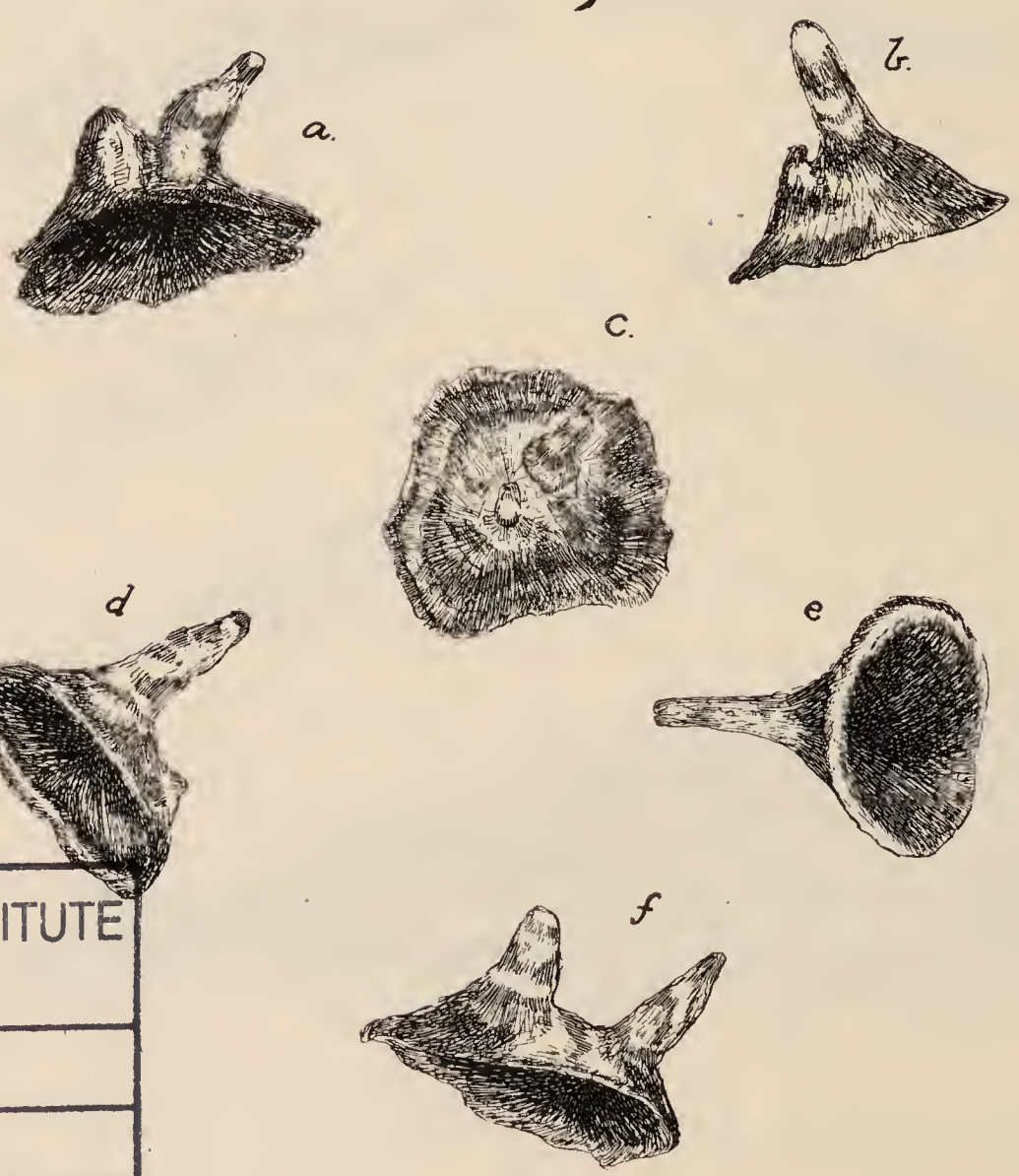

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THE DERMAL ARMOR OF THE STURGEON.

BY GEORGE WILLIAM KOSMAK.

(*Read January 4th, 1895.*)

I.—INTRODUCTION.

The Sturgeon has commanded the interest and attention of almost every nation living near the oceans, great rivers and seas of our northern hemisphere, for several centuries, as history informs us. For many hundred years its economic importance as a factor in the food supply of many peoples, has made it so well known, from the practical standpoint, that Science in our own century has not neglected to make this member of the class *Fishes* the subject of theortical investigation as well.

Explanation of Plates 45, 46, 47, 48.

These figures are from pen-drawings of scutes and derm-denticles which were isolated from the surrounding dermal tissue by KHO. They were taken from Sturgeon about two feet in length, and in drawing them care was taken to maintain the relative proportions, excepting in the case of scutes (Figs. 1, 2, 3), and the derm-denticles (Figs. 4-9),—the latter being enlarged about five times as much as the former. For the actual sizes refer to the text.

PLATE 45. FIG. 1.—Body-scutes from the middle of the dorsal row. FIG. 2.—Scutes from one of the lateral rows. FIG. 3.—Scutes from the ventral rows.

PLATE 46. FIGS. 4, 5.—Derm-denticles from the dorsal faces. These should be compared with FIG. 9. Attention is directed to the ganoid character of the former, and the placoid character of the latter. Each figure shows the object in plan and elevation.

PLATE 47. FIG. 6.—A derm-denticle from one of the lateral faces, shown in plan and elevation. FIG. 7.—Derm-denticles from the tail region. *A*, *b*, *c*, *d*, *e* are isolated specimens, to more clearly show their form and the character of the spines, while *f* shows the arrangement *in situ*.

PLATE 48. FIG. 8.—A derm-denticle from one of the lateral faces. FIG. 9.—Derm-denticles of a placoid type, from the ventral face.

The Sturgeon (*Acipenser*) is generally found in salt water, but, like other members of the finny tribe, may live in fresh water for a time, when it ascends the larger rivers during the Spring for the purpose of depositing its spawn, returning to the sea at the end of the season. Some forms always inhabit fresh water, such as those of our own Great Lakes, and the allied *Scaphirrhynchus* of the Mississippi Valley. The principal fishing grounds of the world for the Sturgeon are the Baltic, Black and Caspian Seas in Europe and the Great Lakes, and the eastern coast of the United States from Maine to Florida, in America. The main products of the industry are the flesh, fresh or smoked, the roe, from which "Caviar" is made, and "isinglass," the dried "air" or swim-bladder.

The growth of the industry has, as in many other cases, largely depleted its numbers,—so, in order to augment the natural increase, various methods of artifically hatching the Sturgeon have been tried, but without material success, as parasitic fungi and other, apparently insurmountable difficulties, prevented the development of the larger proportion of eggs set out. Only within the past two years has a method been devised, after many experiments, by means of which the young fish could be successfully hatched out in numbers sufficient to give the plan a practical and therefore commercial value.*

This evening's paper may more properly be classed as theoretical, and from this standpoint, Biology and Palæontology have honored *Acipenser* and its allies with considerable study and attention.

The Sturgeon occupies a singular position in the scale of Vertebrate development:—a retrograde Ganoid, intermediate between the Sharks below, and the other Ganoids (Gar-pike, etc.), above it, and having some of the characteristic features of each. The scales and other integumentary structures aid in placing our type in this intermediate plane; some, as we shall see later, are of a distinct placoid (shark) form, others

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* The results of this investigation are embodied in a report to the U. S. Fish Commission, by Dr. Bashford Dean, of Columbia College.

are closely related to such ganoid structures as we find in the Gar-pike. In order to better comprehend the structure and relationship of the Sturgeon's dermal armor to the other fish types, it will be well to preface our description of the subject proper by a brief account of fish scales in general, their development and structure.

II.—FISH-SCALES IN GENERAL.

The protective function of the skin of Fishes is greatly enhanced by a system of armoring, made up of various elements of a limy, or horn-like consistency, which may be classed as scales, scutes and derm-denticles. Though these undergo many modifications in form and distribution in the different groups of Fishes, yet they are all derived from the same source, the dermal layer of the skin, with the epidermis taking only a secondary part. We may, however, recognize four pretty constant divisions of scales proper:—cycloid, ctenoid, ganoid and placoid. These terms were employed by Louis Agassiz as a basis for the classification of fishes themselves;—but more rational standards have since been adopted, and his survive as descriptive terms of the scales alone.

The term scales is usually applied to various bone or horn-like structures, of which it is possible to distinguish three somewhat widely differing conditions in Fishes: in the one form we have the skin itself very soft and covered by scales in the proper sense of the word, instances of which we find in the Cod, the Perch and other Teleosts. The other extreme presents a condition of complete nakedness of the skin, as in most Eels, the Lampreys and all Fishes provided with well developed electric organs. A stage midway between these two includes several interesting types which we cannot class in either one or the other of the groups just mentioned; these forms are the Sharks, the Rays and the Sturgeon.

We must recur for a moment to the method of classification of Fishes of Louis Agassiz, based on the form of their scales. It has already been noted, how in time his method became obsolete: it shared the fate of all like systems, which, based on the modifications in structure of one organ, are

necessarily artificial. Yet his work was of great importance, for it opened up a new field of research, by the study and comparison of fossil with living forms. The lines between the kinds of scales cannot be sharply drawn, but one merges into the other. We must base our descriptions, therefore, on the generalities of each group.

(*a.*) *Placoid* scales consist each of a basal plate embedded in the skin, with one or more derm denticles projecting beyond the surface. Such a condition gives us the "shagreen" of Sharks.

(*b.*) *Ganoid* scales are hard and bony, covered by a thin layer of enamel [(?) ganoin], and generally rhomboidal, seldom rounded. They are usually arranged in oblique rows and overlap after the manner of roof-tiles. They are typical in the Gar-pike.

(*c.*) *Cycloid* scales have no covering of enamel; the hinder ends are smooth, and being free, overlap one or more of the succeeding scales; the outer surface is striated in two directions, one set rather coarse, radiating from the center towards the posterior margin, the other, much finer in character, concentric and parallel to the margin.

(*d.*) *Ctenoid* scales are, as a rule, thicker than those last mentioned, and provided with spinous teeth on the hinder edges, of one or all the layers of which the scale is composed.

All scales, scutes and derm-denticles as included in this series are developed as horny or calcareous elements from a dermal papilla, and later become enclosed in a kind of dermal pocket, as best represented in the Teleosts. We can here insert a brief description of these structures as they occur in the characteristic fish types.

Passing by *Cyclostomes*, which have a naked skin without any traces of scales, we come to the *Elasmobranchs*, and in this sub-class shall take the Sharks as a type. In each "placoid" scale can be distinguished a fundamental part, the *basal plate*, and an apical part, the spine or *denticle*. The basal plates are usually rounded or rhomboidal and arranged in rows diagonal to the long axis of the body; each plate is separated from its

neighbors by narrow stretches of skin, which allow for the development of new rows of plates between the rows of the old ones during the growth of the animal. Connective tissue fibres are attached to their lower surfaces from the deeper parts of the derma. The number of spines on each plate varies, some have only one, which may be simple or divided into three smaller points at the free end (*Scyllium*): in others, again, there may be several in one line, with the largest in the center, or they may be scattered over the entire plate.

The under surface of each plate is perforated at the center by a canal which continues into the denticle, and there expands and forms a pulp cavity, with branches ramifying into the substance of the spine.

Oscar Hertwig has verified the very close correspondence in the histological development between these placoid scales and the maxillary teeth in Sharks. The hard covering of the denticle, from its origin, must be looked upon as enamel, and by the agency of polarized light its prismatic structure has been demonstrated, while the interior agrees with the dentine of higher Vertebrates both in chemical and morphological characters. The basal plate still stands in need of considerable explanation as to its true origin and structure. Hertwig considers it as true ossified connective tissue ("verknöchertes bindegewebe"), or in analogy with the teeth of Mammals as "cement." Neither dentine tubules or cells are here present.

The development of the placoid scale has been most closely studied by Hertwig (1876) and Klaatsch (1890) and the results of their researches, very much abbreviated, furnish us with the necessary data for our discussion.—Before there is any trace of scale formation, the integument of *Selachians* agrees closely with that of *Cyclostomes*, and at this stage may be looked upon as representing an ancestral condition. The first indication of a scale formation is a local upheaval of the epidermis, caused by a dome-shaped growth in that part of the derma, called by Hertwig, the "germ-layer," which is richly supplied with blood-vessels and assumes the most important role in the formation of placoid scales.

The dermal papilla grows larger and a differentiation then occurs of its component elements into a mass which presses against the overlying epidermis in the form of a blunted cone, and another which spreads out parallel to the surface in the outer dermal layer. The growth of the two parts continues and results in the pre-formation in cells of the later scale:—the conical part indicating the spine, and the flat mass, the basal plate. The formation of the hard parts now begins: the basal epithelial cells secrete an enamel cap, which begins at the point and extends gradually over the entire spine. The containing cells now take up calcareous matter and form a homogeneous mass,—the dentine. Some cells remain in the pulp-cavity, others are surrounded by the substance of the dentine, but still communicate by processes with the central cavity, and thus originate the dentine tubules.

When the spine is completed, the process of dentine-formation extends over the flat portion of the scale-germ and produces the basal plate. This power of secretion is embodied in certain dermal elements, derived from the germ-layer. The enamel covered spine now pushes its way outward, until the neck is on a plane with the inner border of the epidermis, the process of enamel secretion having also been continued to that point. The dentine of the interior has become very much thickened, with consequent increase in the number of the tubules: the upper part of the pulp-cavity being itself so narrowed as to resemble one of them. A complete denticle now results.

The placoid organs are differentiated in various ways: those in the mouth are specialized into maxillary teeth, those on the body become protective in function. The spinous part may become modified and changed into numerous small or a few large spines. The arrangement of the scales may be greatly altered by the dropping out of some and the formation of others at different spots; and this large number and constant regeneration of the placoid scales characterizes the present Selachians.

Although relatively they approach very closely the original primitive fish type, we must consider the living Selachians as

survivors of a group which has branched off and developed along a definite, unwavering line. We cannot therefore look upon their dermal armor as the prototype of all other fish scales. In this connection it is important to state that the number of scales is far less in young than in adult sharks, and we may therefore recur to a previous condition with fewer scales than in living forms, through which Sharks have passed. This is probably the primitive type of all such structures, and we shall come back to it later.

We must next consider the scales of Ganoids. Several widely differing forms are included in this group of Fishes, established by Louis Agassiz and further defined and elaborated by Johann Müller. The member selected as a type for the discussion of the Ganoid scale is the Gar-pike (*Lepidosteus osseous*). The results here noted are those of the latest researches, of Klaatsch in 1890, and Nickerson, 1893.

Ganoid scales in our type are rhomboidal, arranged in oblique rows, and each so placed that its hinder margins slightly overlap the succeeding ones. In very young specimens, the relations of the scales to each other are different:— on the ventral side they are smaller, and more circular, and between the rows are stretches of skin increasing in breadth towards the ventral median line, so that there are spaces totally devoid of scales in the young, which are fully covered in the adult. At the beginning of their formation we find in the outer layer of the dermis a thin sheet of calcareous matter, completely separated from the epidermis by several layers of dermal secreting cells (scleroblasts). Where blood-vessels pierce this layer, no secretion can take place, and openings through the scale at such places are thus formed. As the scale increases in size and thickness (from both outer and inner surfaces, but more particularly from the inner), "scleroblasts" become enclosed in it, with radiating and intercommunicating canaliculi, and the edges of adjacent scales come close together and overlap, by reason of a slight elevation of the posterior end during the early development. On the lower side connective tissue fibres from the deeper derma also become enclosed, and extending from one

scale to another allow of a flexible connection and articulation. Around the posterior margin of the scales of young Gars are scattered a number of sharp spines, of which there is hardly any trace in the adult fish. They originate independently from cells over the basal plate, under the basement membrane of the epidermis, the inner end joins the basal plate below, and as this grows in thickness, becomes incorporated with it. The cap is secreted by dermal, not epidermal cells, and cannot therefore be classed as enamel, but has been called "ganoin."

Comparing these facts with those of the foregoing type, we notice the following relations: In Selachians, the spine appears first, the basal plate follows; in *Lepidosteus* the plate is formed first, the spine secondarily. In Selachians we always find a less number, though persistent spines; in *Lepidosteus*, a greater number, but transient. The spines are essentially alike, with the exception of the cap, which is enamel in the first group, ganoin in the other. A striking change has therefore become manifest in the transition from the *placoid* to the *ganoid* type. The basal plate has become the important factor; it is formed independently of the spine, which comes on later, but soon disappears.

Hertwig derives the scales of *Lepidosteus* from fusion of numerous basal plates of the Selachian type, each spine representing a primitive placoid scale. There may be some truth in this, but yet his conclusion seems imaginative when we consider the large number and irregular arrangement of the spines on a single *Lepidosteus* scale. A more probable theory may be put forward:—going back to a common prototype, we can consider the scale-formative processes, diverging along two lines, in one all the energies of the dermal secreting cells were devoted to the construction of a spine with a basal plate as secondary, in the other a plate is formed primarily which corresponds to the main body and mass of the other basal plate, with a covering of "*ganoin.*" In the latter type, spines are formed independently of the underlying basal plate, and the hereditary tendency which results in their formation, may also be accepted as the cause of their disappearance, in the same manner as fish-like gill slits appear during

the embryonic life of the chick, only to disappear with advancing growth.

We have now come to the discussion of the highest orders of Fishes:—the Teleosts. In a previous classification were noted cycloid and ctenoid scales. Considering their many variations, nearly all Teleost scales can be traced to one or the other, or to an intermediate type, of these two forms. Examined *in situ* they are seen to consist mostly of thin plates of ossified or horny material, embedded at one end in connective tissue pouches of the derma, the other end being free and overlapping parts of one or more of the immediately succeeding scales. They are arranged in rows diagonal to the long axis of the body. We can dismiss the development of the Teleost scale, with the general statement that they represent a plate of two layers, an outer osseous, and an inner of connective tissue, which has been incorporated during growth to form lamina.

The Teleost scale as it stands alone, is rather puzzling. To properly understand its position, we must attempt to derive it from, or at least correlate it with, the forms we have already described:—the *placoid* and *ganoid* types. It is believed that the Teleost scale tallies with the basal plate of the *placoid*, especially of the upper part. Other proofs are also at hand to strengthen this assumption; there are, in fact, numerous examples of deviations and anomalies from the standard. Thus we have Teleost scales with well-developed spines, one or more in number, and it has been asserted that the centrum is the seat of a former spine. The relation to *placoid* scales has thus been established, but the connection with the *ganoid* form is not so definite. Lepidosteus scales up to a certain stage of their development, may be looked upon as an intermediate form between Teleosts and typical Ganoids, though in the course of evolution they have undergone many specializations. Certain conditions were then discovered in "*Amia calva*,"—the survivor of a large family of fossil Ganoids,—which greatly aided the establishment of final definite relations between Ganoid and Teleost. This fish probably stood very close to the prototype of all Teleosts, but was supplied in

addition with many other features of the Ganoids. The scale of *Amia* is made up of two layers, an outer, containing osseous elements, and inner layer without these, but laminated. Like conditions are found in Teleosts. Then Palæontology furnishes the link by which the rhomboidal Ganoid are finally connected with the Teleost scales by bringing to light intermediate forms of Ganoids with cycloid scales and Teleosts with ganoidal scales.

Let us now compare the three types which have been examined: Selachian, Ganoids and Teleosts.—We notice first of all the general arrangement of all scales in oblique rows. [Rows of *scutes*, such as are possessed by the Sturgeon, are in general parallel to the long axis of the body.]

The Teleost derives only the superficial part of the basal plate from that of the *placoid* scale ; there are wanting, therefore, the deeper layer and usually the spines. The under layer is of a secondary formation.

For the growth of new scales in Selachians sufficient space has been provided between those already developed. In Teleosts, similar conditions occur only in the early ontogenetic stages.

The *ganoid* scale, lying almost parallel to the body surface, is destined to grow most in thickness, continually taking up parts of the cutis and incorporating them in its substance, thus securing a more intimate connection with the connective tissue of the skin. The growth along the edges proportional to the growth of the animal, is very small. Compare with this the Teleost scale which is imbedded at one end in a pocket of the derma, and therefore necessitates a growth at the free margin only. It fits loosely in its pocket, for it does not incorporate any connective tissue with it, but grows by a complicated secretive process.

Though the relations are more difficult to establish, it is evident that the typical Teleost scale approaches nearer to a Ganoid than a Selachian form. Klaatsch (Morph. Jahrb., Vol. XVI.) has constructed a diagrammatic scheme which greatly simplifies the comprehension of these facts. By this it will be seen that the various forms of modern fish scales are the ter-

minal points of lines radiating from a common center, which may be represented by a Selachian-like prototype:—"rhomboid plates in rows from the center of each a spine arising." This condition persists to a certain extent in modern Selachians, the increase in number of spines and the thickening of the basal plates being secondary and later modifications. The spine may be reduced and the basal plates be extended horizontally, until one touches the other. Thus we have a transition from a primitive *placoid* to a primitive *ganoid* scale. A further thickening and definite rhomboidal form now ensues, with close connection of individual scales by ligaments and an overlapping of the margins. This last type then breaks up into many smaller divisions, with two main branches, one represented by *Lepidosteus*, the other by *Acipenser*. In a totally different direction a series branches off from the prototype of the Ganoid scale, which furnishes the link between Ganoids and Teleosts, in *Amia* and others before noted, and which leads to the *cycloid* and *ctenoid* types. These remarks conclude the introduction to our subject proper. It is hoped that they have been made clear enough for the better understanding of what follows.

III.—THE SCALES OF THE STURGEON.

Gunther places the Sturgeons proper and their related forms in the Sub-order Chondrostei, which he divides into two families: Acipenseridæ, or Sturgeons proper, including the genera, *Acipenser* and *Scaphirhynchus*, and Polyondontidæ, with the genus *Polyodon*. The Acipenseridæ form a well-defined family, geologically the youngest of the Ganoids, which have halted in the process of evolution at an early stage. This is well shown in the peculiarities of their armor as it is studied in detail. The descriptions were taken from two specimens of *Acipenser sturio*, of a little more than 50 cm. in length (as these would best present the conditions between young and adult forms), and with them have been compared young fish of 14 and 19 cm., and a large specimen of about 1.75 metres.

Upon examining the surface of the body, we notice that it is divided into five faces, which on cross-section cause it to

present a pentagonal outline. The five main rows of scutes form the angles of these faces, and the intervening stretches of skin are studded with many derm-denticles. The faces we may designate as right and left dorsal, right and left lateral, and ventral. At any given section, except at the extremities of the body, they are of almost equal breadth, the lateral perhaps a trifle wider. The dorsal crest of the body falling away anteriorly, causes the dorsal faces to merge into one on top of the head. The lateral faces extend from the front edge of the operculum, narrowing posteriorly, to the point of insertion of the caudal fin. The ventral face forms the flat under surface of the body, runs forward under the rostrum, but back of the anal fin is merely wide enough to accommodate the post-anal plates. This peculiar contour and outline presented by a cross-section of the body differs greatly from that ordinarily found in Fishes, where the element of form is an ellipse, with the long and short axes in varying relations to each other.

In our description of the dermal armor it is well to commence with the structure and arrangement of the large scutes found disposed in five rows, each running almost the length of the body.

A.—Dorsal Scutes.

Extending from the last of the fused head-covering bones to the dorsal fin is a row of eleven large scutes, which number is constant for all of the species. The external surface is made up of two faces, inclined in the first at an angle of about 135°, but decreasing in next to the last, to an angle of about 90°. The first is the largest, the others become smaller in proportion to the decrease in body surface, towards the tail. The anterior ones are broader than long, the posterior ones the reverse. The outline is irregular: the sides are deeply serrated, the front is produced forward into a blunt spine, the hinder part is notched at the middle line. The skin unites with the scute and covers the serrated part, and also extends over the articulation between two neighboring scutes, which is formed by a ridge and spine on the front end of each fitting into a notch on the hinder margin of the one preceding. This construction allows of movement in all directions.

The surfaces of the scutes are studded with radiating rows of small, irregular, spinous projections, those of one row connecting with some of an adjacent row by little ridges. The junction of the two faces of each scute produces a well-marked crest of varying outline. Three parts can be distinguished in this:—an anterior part, which begins at the point where the skin which takes part in the articulation with the previous spine is attached. In the first scale this part of the crest is continuous with that of the fused head scale in front of it, and in the last scale, from the nature of its faces, it is absent altogether. Serrations commence in front, decreasing in size towards the central spine, and probably result from the fused spines as found on the other parts of the surface. I have noticed that these serrations are most pronounced in the medium sized specimens. The middle part of the crest, constituting its most prominent feature, is formed by a spine, with its point directed caudad. In the young the point is sharper and smoother than in older forms, but in all it grows more marked as we pass caudally. The posterior portion of the ridge runs from the spine to the hinder margin of the scute, and slightly overhangs the median notch. The serrations here are stronger and deeper than in the anterior part and probably result from the same cause; in the last scute it is necessarily absent, and in the next a mere trace. The entire ridge undergoes several changes during the growth of the fish; it is more regular in the youngest forms, that is, the serrations are not so extensive or pronounced, and the anterior and posterior parts are of almost equal and constant length, as opposed to older specimens, where we find the anterior part the larger. In the fully developed adult the crest and its spine have almost totally disappeared;—this fact will be spoken of again later on.

The scutes are all of nearly the same outline in young, but become greatly changed in adult forms, as can be seen by comparing the plates. These variations are undoubtedly due to mechanical agencies:—lateral movements of the fish would tend to the compression of the hinder ends, as the foreshortened central scutes plainly show. This same movement also prob-

ably gave the middle scutes their steeper pitch, as in younger forms the angle is more uniform.

Before leaving this main row of dorsal scutes, the modifications that occur around the last one must be noticed. Instead of remaining a single plate, it may become divided in the median line, or there may be one or more separate smaller plates intercolated between it and the preceding one, which are flat, rhomboidal and studded with projections similar to those on the other plates. The spine of this last of the dorsal row of scutes articulates with the fulcrum of the dorsal fin, on each side of which is found a row of spinous, rhomboidal, flat plates, of a later development than the others. Posterior to the dorsal fin are two irregular rows of plates, decreasing in size towards the tail, crowded more closely together with the growth of the animal, until they become fused in the adult; the last of these are narrow and elongated, pointed in the back and notched in front, overlap and articulate, and continue as the fulcra of the dorsal margin of the tail.

B.—Lateral Scutes.

These vary in number on both sides of the body in the same individual;—generally twenty-eight or thirty. As in the dorsal scutes, this is a zoological count, and morphologically we may include two others, which are fused with the head scutes and function as part of the secondary shoulder-girdle. They are counted therefore from this point into the base of the tail. Like the dorsal their surfaces are made up of two faces, inclined at a large angle to each other in the greater number, but decreasing near the tail. The central crest is not so pronounced, yet the spine is much more developed and sharper than in the dorsal scutes. In shape they are not so irregular as the others: the majority about twice as long as broad, with the last few about the same dimensions in both directions. In outline they are nearly smooth, rounded at the upper, pointed, and with one or two serrations at the lower end; the anterior margin is very smooth, with large projection and notch over the middle line of the scute; the flattened part underlying the scute immediately in front, forms with the aid

of a notch* in the otherwise quite smooth anterior edge, a skin-covered articulation. The entire edge is much thinner than the rest of the scute and is covered by skin. We must in conclusion mention also the spinous projections on the surfaces, and the general forward inclination of the scutes.

C.—Ventral Scutes.

We can differentiate two main rows of these, extending from the pectoral to the anal fins; there are generally one or two more on the one side than on the other, so that they number from nine to eleven on either side. Corresponding to the pinkish-white color of the belly, they also appear light in tint (owing to the lighter pigment in the overlying epidermis). The two faces unite in a central spine and crest, the anterior end of which is continued with the margin of the scute into a long spur, which, with a notch in the hinder end of the next scale, forms an articulation. In the last scute this spur is not always covered by the scute in front, but projects outward from the middle line; this occurs generally in that row which contains the least number of scutes. The last members on each side articulate with the fulcra of the anal fins. Posterior to the spines, the junction of the faces is not angular, but rounded, and therefore no crest is present. The margins are deeply serrated, thin, and covered by skin, without such spiny projections as are found in radiating lines from the central spine, on the remainder of the scale.

Anterior to those we have just discussed are four others which from their position and general features we can class morphologically as ventral scutes. They form the lower part of the supplementary dermal shoulder girdle, and are closely connected with those of the upper side and form the boundary of the gill-opening on its one side. The outer two articulate by a socket with the pectoral fin, the other two may be considered analogous to a sternum.

Between anus and tail we have a series of scutes similar to those directly above them on the dorsal side. Directly in front of the anus we have the pre-anal plates, four or more in

[* This cannot be made out in the posterior scutes.]

number, loosely set in the skin and not appearing in the youngest specimens examined, because the ventral scutes come so close together as to leave no room for their growth. The post-anal plates number four or five, with the two nearest the anus generally free in young forms, but closely articulated or even fused, in adults (especially the last two). [In one young fish was noticed a larger central plate with the others grouped around it.] Back of all these is a scute; flat in front, with projections which fit into spaces left between the hinder ends of the last post-anal plates. The posterior end of this scute is continued into a process which articulates with the fulcrum of the ventral fin. On each side of this fin we have a number of flat plates, increasing in size posteriorly; the two immediately behind the fin unite, and the last one very elongated, articulates with the caudal fin.

D.—Derm-denticles.

Between the five rows of large scutes just considered, are scattered through the skin a large number of the so-called basal plates furnished with projecting spines, the denticles. Their arrangement is not very regular;—if the body be slightly twisted in a direction across the long axis of the animal, the skin falls into a great number of small wrinkles, each of which contains an irregular row of derm-denticles. On those parts of the head where no scutes occur they are also thickly scattered. Specimens from various parts of the body were isolated from the surrounding tissue by KHO and studied, to detect any differences in form and structure, due to location. Microscopic sections were also prepared for an intended study of histological characters; but the nature of the material made the cutting difficult, even after trying various methods of decalcifying.

Generally speaking, the derm-denticle consists of a basal plate, with one or more spines arising from it, not formed independently, but as part of the plate. The spine is elongated, solid, and projects beyond the surface of the skin. On the dorsal surface are comparatively large rhomboidal plates, bearing short blunt spines arranged in various ways:—

I have observed plates with a group of spines in the center and one at each corner, some with three or four spines in a row, others with them scattered irregularly over the surface. On the lateral faces we find two kinds of derm structures:— one resembling the basal plates of the dorsal faces but more irregular in outline and not so large or containing so many blunt spines, the other has a smaller but thicker basal plate hollowed out on the lower surface, with a corresponding rounded upper face, bearing two, sometimes three or four pointed spines in a row, the central one always the larger. These latter plates are nearly elliptical in outline and found irregularly scattered among the others. (Fig. 8.) On the ventral surface we also have two varieties, but the larger plates are more rhomboidal, and furnished with a less number of blunt spines than those of the other faces. The other kind agree with the rounded ones of the lateral faces, except that the spines may be larger and more pointed. (Fig. 9.)

On the sides of the tail we find some curious conditions. Here we have plates somewhat elongated, though their quadrangular shape can be plainly made out; thickest in the middle, tapering towards the long ends. They measure from three-eighths to one-half an inch in length, and about one-sixteenth at the widest part. Their edges come close together but do not overlap; they form rows, which in one direction are parallel to the dorsal edge of the tail, and in the other are inclined to it. Diagonally across each scale, connecting the two lesser angles, is a spinous ridge, the constituent spines of which are seldom regularly disposed. (Fig. 7.)

On examining sections cut from this region, I could not distinguish any histological difference between this form and the other derm-denticles of the body—all seem to be a homogeneous mass without Haversian canals, or other such structures. Having thus briefly examined the various parts which make up the dermal armor of the Sturgeon, we must compare the results with the conditions found in other fish types and endeavor to show from what forms it has been derived and to which most nearly related, that is as far as the integument is concerned.

Before comparing it with other fishes, however, a few relations between the scales of the Sturgeon itself, must be noted. If specimens of the young and adult be contrasted, several striking differences will at once become apparent. The scutes of the young fish lie closer together and overlap each other more than in the adult; the spines are more pronounced and smoother in outline and their points sharper than in larger forms,—in fact, in the fully grown Sturgeon they disappear altogether. The other projections on the body of the scute, are indicated in the young by lines radiating from the large central spine; in the largest specimens these have become very marked, but blunter, and connected with each other by ridges, so as to give the entire surface a very rough and pitted appearance. It seems that all the secretive energies of the young scute are directed to the formation of a sharp spine, while in the adult where this has disappeared the process of ossification is merely employed to thicken the scute. Judging by a taste prevalent in the members of the human species, the flesh of the Sturgeon must also prove an agreeable article of diet to the fellow inhabitants of its native lakes and rivers. The full-grown adult forms are too large and swift to be sought after by any but their human enemies, but the young would more easily become the prey of other fishes were it not for the protection afforded by the development of the recurved spines on the scutes, which would undoubtedly prove an unwholesome morsel for even a piscine gullet. We thus see how nature has protected the young Sturgeon against its enemies by passive means of defence in the form of very sharp spines; in the adult fish, which is not subjected to such dangers, they are no longer necessary and are gradually absorbed.

IV.—CONCLUSION.

A resumé of the discussion relating to the derivation of all fish scales from a common prototype was given on a preceding page, the results noted being mainly those of Hermann Klaatsch. In his diagrammatic scheme the scales of *Lepidosteus* and *Acipenser* are placed at the ends of two co-ordinate

branches, both arising from a type which had thickened, rhomboidal scales, closely connected by ligaments and overlapping. He considers *Acipenser* as presenting a secondary reduction of the scales which in the ancestral *Palæoniscidæ* served as a highly protective dermal armor.

The Sturgeon having thus been given a position on a genealogical tree of scale forms, as it were, let us see by what factors, as presented by the study of the various scutes and derm-denticles of our type, we can link *Acipenser* to other fishes immediately above or below in the animal scale. The results which we employ are, of course, based on external characters only;—they should be further strengthened by careful histological and embryological studies, but let that furnish the subject for another paper.

Two principal varieties of dermal structures we noted in our type. One, in the form of more or less rounded basal plates with spines, approximates very closely to the placoid scale of Selachians. (Fig. 9.) The basal plates in this case are thin and hollowed, and the spines quite long and sharp. In the other case, the basal plates are flat, square, and much thicker, with short and more blunted spines (Figs. 4, 5);—the entire structure very much like the ganoid scales of *Lepidosteus*, the change in outline probably due to specialized conditions, though some (Fig. 5) have preserved an almost unbroken margin.

These are the predominating varieties of derm-denticles, but in addition we must consider two other forms of dermal structure. From what is known of the large body scutes, they can probably be classed with the ganoid type;—the evidence is furnished by fossils, and will be spoken of presently. Figures six and eight present a form somewhat more uncommon than the other derm-denticles. These have hollowed basal plates of a stouter character than the distinctly placoid types, with correspondingly greater spines. Comparing figures six and seven, we can detect certain points of similarity which might lead to the thought that the former are degenerate forms of the latter (Fig. 7, c, d.),—degenerate in so far as they have approached the more primitive Selachian type. One

thing that stands in the way is the question of their relative sizes, as one is three or four times the size of the other. If we suppose, however, that separation from its neighbors gave more room for growth, this objection may perhaps be set aside.

A glimpse at a closely related fossil Ganoid will aid in clearing up to a certain extent the relations of all these structures to each other, and also their derivation.

The *Palæoniscidæ* of Palæozoic time have close affinities with our modern Sturgeon. They exhibit similar skeletal features, but were totally covered with scales resembling very much those of the Gar-pike. It is possible to detect slight divergences from the regular arrangement and form of the scales, in lines which approximate closely in position with the scutal rows of the Sturgeon. Bearing this fact in mind, we can assume that a further specialization of these scutes may have taken place, while the intermediate scales were either lost or degenerated. This degeneration can be represented at one stage by the structures shown in Figs. 4, 5. But degeneration also occurred in another direction,—a reversion, an atavism (if we can presume to call it so) to a primitive type from which the *Palæoniscus* itself also probably descended. This reversion we see in such forms as are represented in Fig. 9. The comparison between Figs. 6 and 7 has already been noted, but whether these points of similarity will warrant the belief that Fig. 7 represents a step in the degeneration of the form in Fig. 6, will remain doubtful until further evidence can be brought forward.

The tail region of Fishes in most cases has remained unchanged while other parts of the body may have undergone differentiations in the course of time. If we suppose that *Acipenser* halted at a certain point in its evolution, why not assume that the dermal structures in the tail region had reached the form we recognize to-day, while the other, body scales, had advanced much further. In a certain sense, therefore, they hold a position between the ganoid form and the primitive, Selachian-like prototype,—but of course much nearer the ganoid form.

The other, distinctly placoid scales which were described are probably the result of an independent retrogression. The scales represented in Figs. 4, 5, however, I look upon as directly descended from the ganoid type of *Palæoniscus*. By some means becoming separated one from the other during the evolutions of the Sturgeon, their exact form of growth was not interfered with, which may account for the irregular outline of many, but other characters are like those of a typical ganoid scale.

In conclusion, we may look upon the Sturgeon, as already stated, as having been suddenly halted in its evolution. Its ancestors, the *Palæoniscidæ* and others, point to a more fully armored form, with scales closely related to those of the Garpike. But the halt in its evolution also induced a retrogression in one direction and a specialization in another:—many of the ganoid scales disappeared, while some remained in a simpler form, and others were specialized into the five rows of body scutes. The hereditary tendency to assume the characters of a prototype is also well shown in the appearance of distinct Selachian scales.

Nature is ever ready to compromise. In another instance we found a form, *Amia calva*, to mark the transition from Ganoid to Teleost, and here we have a type, with common characters, which can be placed in the scale of Vertebrate life, between Selachians and the other Ganoids.

SOME REMARKS ON CLARIFICATION, AND ALSO ON A NEW CLARIFIER FOR MICROSCOPICAL PURPOSES.*

BY EDWIN A. SCHULTZE.

(*Read October 19th, 1894.*)

One of the most important points to be observed in microscopical research is the requisite clarification of the object under examination. As simple, however, as this appears, the views of the different authorities who have investigated the subject do not appear to coincide. In studying plant sections clarification, according to Dippel, is resorted to to produce the necessary transparency of the object, which on account of its contents does not permit of a thorough investigation of the inner structure. The usual clarifiers mentioned by Dippel are: Liquor potassæ (in some cases to be used with acetic acid and ammonia); potassic alcohol, carbolic acid (when necessary to be used after treatment with alcohol or mixed with turpentine), and finally chloral hydrate (8 parts dissolved in 5 of water). Zimmermann, in his work "Botanische Mikrotechnik," discriminates between the action of the above named chemical clarifiers and the clarification by means of more or less refractive mounting media, especially essential oils, balsams and resins. Of these latter he mentions Canada balsam, dammar and Venetian turpentine. Tschirch, in his "Pflanzen anatomie," speaks of employing only liquor potassæ and potassium chloride, with acetic acid for clarifying plant sections.

Moeller, to conclude, very correctly places water at the head of his list of clarifying reagents; then follow glycerine, alkaline solutions, Javelle water, and finally chloral hydrate. There appears to be a difference of opinion among the author-

* Translation from the German of Dr. Wilhelm Lenz. Zeitschr. f. wiss. Mikr. xi. 16 (1894).

ities on this last mentioned clarifier, which Schimper frequently and highly recommends. Behrens, in his extensive catalogue of clarifiers, calls attention to chloral hydrate "as being only useful for animal preparations" without naming his authority. Moeller mentions chloral hydrate (5 parts in 2 of water) as having been recommended by A. Meyer, and refers to a publication of this last named authority in the "Archiv der Pharmacie," but in which chloral hydrate does not appear. Moeller says, furthermore, that chloral hydrate is preferable to diluted liquids, inasmuch as it leaves the fecula unchanged.

Such is, however, not the case, for it is easy to demonstrate that chloral hydrate causes every kind of starch to swell and change into a pasty substance after about 24 hours' time. The formation of this transparent paste does not in any manner interfere with the admirable clarifying properties of chloral hydrate.

I have used chloral hydrate (8 parts dissolved in 5 of water) to a great extent myself as a clarifier for plant sections, and have also recommended its use to those students interested in microscopy at the Fresenius College in this city, and believe I have thoroughly investigated its advantages and disadvantages while comparing it with other clarifiers. A short communication may, therefore, be acceptable on this as well as on a similar clarifier lately discovered by me, and which, I think, is somewhat superior to chloral hydrate.

As already stated, Dippel has explained in a masterly manner the reason for clarifying plant sections. The means for obtaining this result are, 1, the removal of troublesome substances, and 2, the saturation of the object under examination with a body, the refractive power of which is so nearly equal to that of the cell walls, that the light may penetrate as much as possible; but still sufficiently different to admit of the cell walls appearing sharply outlined under the microscope. The division of clarifiers into chemical and physical by Zimmermann, seems to have originated in the above, yet I cannot agree with him for the reason that most of the clarifying solutions act chemically as well as physically, in consequence of

which they must be carefully examined and used accordingly. This is especially the case with chloral hydrate. Its excellent double action, chemical and physical, and consequently the ease with which it may be used, has rendered it a very desirable clarifier.

It is remarkable that as yet so little is known of the physical properties and refractive power of the chloral hydrate solution. According to my researches a solution of 8 parts c. p. crystallized chloral hydrate in 5 parts of water has a specific gravity of 1.3677 at 15° C. The refraction of sodium light is 1.4272, and the divergence 0.0078. I have not been able to discover the refraction of pure cellulose.

If we consider, however, that pure cellulose is clarified almost to invisibility in Canada balsam, while remaining clearly perceptible in glycerine of less and styrax of greater refractive power, we may conclude that the refraction of cellulose is about that of Canada balsam. The mean refraction of the latter is said by Behrens to be 1.535.

There are a few drawbacks which must be mentioned in using chloral hydrate as a clarifier. While the action of the alkaline solutions may be nullified with acetic acid, and any turbidity removed with ammonia, this is not the case with chloral hydrate. Fecula and almost the entire contents of the cells are more or less dissolved by chloral hydrate and rendered transparent. In treating these clarified objects with water or glycerine they become turbid.

These defects are far less perceptible in a solution that I have been using for the past six months, and which is composed of equal parts of sodium salicylate and water. This solution has a specific gravity of 1.2315 at a temperature of 17° C. Refractive power 1.4497 and divergence 0.01318 at 15.4° C. According to my former observations the refractive power of the chloral hydrate solution would equal that of a 67 per cent. solution of glycerine. The salycilate solution, as I shall call my new liquid, shows a refraction equal to that of a solution of 82 per cent. of anhydrous glycerine. The penetrating power of my solution is greater than that of chloral hydrate on account of its low specific gravity. Its refractive power is

superior to that of chloral hydrate without, however, approaching too closely that of cellulose. It is, therefore, for both reasons, more serviceable as a clarifier than chloral hydrate.

As far as its chemical clarification is concerned the action in swelling the fecula is very prompt. No starch grains were perceptible in sections of ginger after they had lain in the solution about two hours. The coloring of the cell walls is also less changed by salycilate than chloral hydrate.

The latter also gradually causes the cell walls to swell, and, in the case of soft structures, they are sometimes rendered partially imperceptible.

In using salicylate I have not discovered this defect; it appears, on the contrary, to have a hardening effect on soft tissues.

If, as an instance, several thick sections of ginger-root, after having lain about 24 hours in salicylate, and the superfluous liquid carefully removed with filter paper, be mounted in glycerine and examined, the cell walls will be found to be but little swollen, and their color, especially that of the cork cells, well preserved.

All the thin strata appear sharply outlined.

In balsam mounts the details become even more clear and beautiful.

In objects which have been treated with chloral hydrate the cell walls will be found more swollen, their color fainter, their outlines less clearly defined, and the structural details, although in general discernible, somewhat obliterated.

Chloral hydrate is, consequently, only serviceable in examining thick objects, and when these are to be decolored as much as possible. Dyes containing tannin are more influenced by chloral hydrate than by salycilate. The best way to eliminate them is by means of alkaline solutions and afterwards, when necessary, with Javelle water.

Fecula, when swollen in chloral hydrate, forms a transparent jelly, which becomes considerably turbid when a small quantity of water or glycerine is added; a turbidity which increases and forms a thick deposit if this supply is increased.

The jelly produced by fecula swollen in salicylate is much more transparent, does not become cloudy through the addition of concentrated glycerine, and remains, when treated with water, moderately translucent. The swelled fecula reacts with iodine in both cases, but producing two different colors, viz.: the chloral hydrate a red, and the salicylate a pure blue. Salicylate with iodine would, for this reason, be valuable for discovering traces of starch.

Salicylate in general has the advantage of containing a neutral, non-corrosive, non-poisonous and non-hygroscopic salt, its principal chemical virtue being an extraordinary power for swelling starches. The chief feature, however, which renders salicylate so admirably useful in microscopy, is its miscibility with phenols, notably oil of cloves. If one drop of oil of cloves be mixed with 10 of salicylate an opalescent liquid will be obtained, which becomes clear by adding a second drop of oil of cloves. If this process of adding oil of cloves be continued, about the 20th drop will produce a cloudy solution, which may be clarified by a single drop of salicylate. A liquid may thus be obtained with a refractive index of 1.5, which is about that of cellulose.

OXIDE OF ZINC ACCIDENTALLY CRYSTALLIZED.

BY FREDERICK KATO.

(*Read November 2nd, 1894.*)

The crystallized forms exhibited are accidental in so far as there was no intention to produce the substance. It has been found at various zinc and iron furnaces, and in roast and slag heaps in both Europe and America, and it is usually described as "Artificial Crystals of Zincite." Numerous references to occurrences and the literature pertaining thereto are given in Dana's "New System of Mineralogy" (1892), p. 208. This artificial product is crystallographically of interest, because the crystals composing it are, usually, symmetrical and sharp angled; whereas the crystals of the native oxide of zinc, or zincite, are not only extremely rare, but seldom as sharply defined and perfect.

The conditions under which the crystals shown were produced are as follows: in a certain trade requiring the casting of metallic zinc, commercially known as spelter, the metal is fused in graphite crucibles. The bottoms of these gradually burn and wear off, until some time, when a crack or hole is produced in the thinned wall, the fused metal they contain leaks out in drops or a small stream into the surrounding coal fire. The metallic zinc, coming into contact with the glowing coals, ignites and burns with a green flame, forming an oxide, known as zinc white. This zinc oxide vapor, in passing through the coals on its way to the chimney, finds suitable conditions for deposition and crystallization, and it is found attached to the cinders, cementing these together in lumps, and also attached to the crucible.

The deposit varies much in color and character. Sometimes it is chalky in texture and with a mammillary surface, but often it is variously crystallized, as shown. Its color is most usually pure white, though light green and wine yellow

are common. The crystals are sometimes transparent. They are sometimes short and stout, or slender and capillary, or again grouped in radiating balls, bristling with fine points. They are generally hexagonal prisms terminated by hexagonal pyramids, or quartzoids, that is they very much resemble quartz crystals in form.

For comparison, artificial crystals of zinc oxide, from the slag heaps of the Passaic Zinc Company, of Jersey City, N. J., are shown, these being much larger, different in habit, and with a beautiful iridescent surface.

PROCEEDINGS.

Meeting of October 5th, 1894.

The Vice-President, Dr. E. G. Love, in the chair.
Thirty persons present.

Mr. J. D. Hyatt addressed the Society on "Some peculiarities in the Structure of *Cicada septendecim*, the seventeen-year Cicada." This address was illustrated by black-board drawings, and by mounted objects as noted below.

Dr. E. G. Love addressed the Society on the habits and structure of *Cicada septendecim*, and his address was illustrated by prepared slides, photomicrographs and specimens as noted below.

OBJECTS EXHIBITED.

1. Madroporic body of Star-fish: by G. W. Kosmak.
2. Embryo of *Cicada septendecim.*
3. Larva of the same just emerged.
4. Stridulating apparatus of the male of the same.
5. Photomicrographs; embryo and young larva of *C. septendecim.*
6. Specimens; imago of *C. septendecim* ♂ and ♀, imago of *C. tredecim* ♂ and ♀, imago of *C. pruinosa* ♂ and ♀, larva and stridulating apparatus of *C. septendecim*, spores of the fungus, *Massospora cicadina* Peck, from the abdomen of the same, and the Digger Wasp, *Sphecius speciosus.*

7. Photomicrographs of sections of tabular quartz from Thomaston, Ga., and of conglomerate from Brooklyn, N. Y. Exhibits Nos. 2–7, all by E. G. Love.

8. Larva of *Cicada septendecim*: by J. D. Hyatt.

9. Mouth-parts of the same: by J. D. Hyatt.

10. Ovipositor of the same: by J. D. Hyatt.

11. Anterior leg of larva of the same: by J. D. Hyatt.

12. Specimen of *Vespa crabro* L.: by J. D. Hyatt.

13. Specimens of the "Snow Flea": by J. D. Hyatt.

Meeting of October 19th, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Thirty-four persons present.

Mr. E. A. Schultze read a paper, entitled "Some remarks on clarification, and also on a new clarifier for microscopical purposes." This paper was a translation from the German of Dr. Wilhelm Lenz, and is published in this number of the Journal, p. 22.

OBJECTS EXHIBITED.

1. Resolution of *Amphipleura pellucida*, mounted in realgar (artificial): by Henry C. Bennett.

2. Antenna and anterior leg with antenna cleaner of the male Leopard Moth, *Zeuzera æsculi* L.: by J. L. Zabriskie.

3–8. Hymenopterous parasites of lepidopterous eggs; *Cosmocoma euchariformis*, *Eustochus atripennis*, *Alaptus minimus*, *Camptoptera papaveris*, *Gonatocerus flavus*, *Anagrus incarnatus*: by E. G. Love.

9. Twelve photomicrographs displaying both the ♂ and ♀ of the above parasites: by E. G. Love.

10. Oolitic sand from Great Salt Lake, Utah: by F. D. Skeel.

11. Foraminiferous sand from Newport, R. I.: by F. D. Skeel.

12. Whale-louse from head of whale: by F. D. Skeel.

13. Segmented eggs of Sea-urchin, *Toxopneustes*. Various stages, from two-celled to blastula stage, the latter also shown in section: by G. W. Kosmak.

14. One and one-half inch home-made eye piece: by ALFRED KROGER.

Mr. Bennett described the artificial production of the medium in which his exhibit was mounted: 1 part of sulphur to 1.7 parts of arsenious acid, the realgar being condensed on the cover glass and then fused on the slide.

Mr. Zabriskie stated concerning his exhibits:

The European Leopard Moth, the larva of which was observed in Central Park, New York City, by Dr. E. B. Southwick, in 1884, became established in this region about the year 1887. It is said to be more abundant and more destructive to shade trees in the City of Brooklyn and the immediate vicinity than it is at present in any particular locality in Europe. Col. Nicolas Pike observed it in Brooklyn in 1888, and found it widely spread over the region in 1892. The eggs, laid in groups with a fluffy covering, hatch early in June. The young larvæ cluster for some hours, and then separate for their destructive work, frequently boring in the trunks of trees, ultimately leaving a burrow nearly half an inch in diameter, and consequent large patches of dead bark and dead wood, but more frequently entering at the junction of two limbs of trees, being the most usual cause of the abundant broken limbs strewed upon the ground or pendant in the trees, as seen here after a storm. Col. Pike lists twenty-four species of trees as ravaged by this moth in Brooklyn, and Dr. E. B. Southwick lists twelve species attacked in Central Park, New York City. The remedies proposed are arsenical sprays, and injection of carbon bisulphide into the burrow followed by stopping with putty (Southwick).

The male antenna is broadly pectinate for full one-half its length from the base. A stout prong extends horizontally from either side of each pectinated joint, and each prong is well furnished with white bristles also extending horizontally. The antenna cleaner is found in both sexes, but is largest in the male. In this case it is an unusually large movable spine, attached at the basal end of the anterior tibia, closely applied to and nearly as long as the tibia itself.

Dr. Love explained that the hymenopterous parasites exhib-

ited by him were prepared by the late Mr. Frederick Enock. They are beautifully mounted in balsam, with wings and legs extended, and the largest specimen measures scarcely one-twentieth of an inch in length.

Dr. Skeel said that his oolitic sand was found in quantities on the shores of Great Salt Lake, and that the grains show a remarkable similarity in size and form, being all ovoid. And further that the whale-louse was one of a great number found in a hole in the head of a whale, the tarsal claws enabling the creatures, when living, to clasp a needle or a bristle with great tenacity.

Meeting of November 2d, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Thirty-two persons present.

A communication from Dr. Arthur Mead Edwards, of Newark, N. J., was read, entitled "Microscopical examination of dust which fell off the coast of Africa."

OBJECTS EXHIBITED.

1. A new formula, 1-12 inch homogeneous immersion objective of E. Leitz: by Charles S. Shultz.

2. Eye-piece micrometer of exceedingly fine platinum wire of E. Leitz: by Charles S. Shultz.

3. Transverse section of stem of *Nuphar luteum*, polarized: by Thos. S. Nedham.

4. Oxide of zinc, crystallized, an accidental furnace product: by Frederick Kato.

5. Section of cork compared with Chinese rice paper: by F. W. Leggett.

6. Section of opalized wood with precious opal from Australia: by James Walker.

7. *Plumatella*, living, by A. D. Balen.

8. An old home-made microscope: by A. D. Balen.

9. Scales of *Lepisma saccharina* under a 1-inch objective: by T. B. Briggs.

10. Preparations of the metamorphoses of the edible frog, *Rana esculenta*, in alcohol: by Henry C. Bennett.

President Schultz gave an account of his late visit to the manufactory of Mr. E. Leitz, Wetzlar, Germany, a large establishment entirely devoted to the manufacture of microscopes and their accessories, everything being conducted on the most systematic plan. He was especially interested in the production of objectives on a new formula, of finest workmanship, of moderate price and having interchangeable parts. Parts of these objectives were mingled together in his presence and then reassembled with entire satisfaction.

Mr. Kato donated specimens of his crystallized oxide of zinc for distribution among the members.

Mr. Henry C. Bennett explained his preparations of the frog: "This is an exhibition of the metamorphoses of the Edible Frog, *Rana esculenta*, preserved in alcohol, and prepared by W. Haferlandt of Berlin. The specimens are all fastened in order on the surface of a milky glass plate, 3 by 14 inches in dimensions, which is immeresd in alcohol, contained in a tall rectangular glass jar measuring internally 2 by $3\frac{1}{2}$ by 14 inches. The five small test tubes containing eggs and larvæ are held to the glass by a very thin thread, and the tadpoles and frogs are also secured to the plate by threads so passed through the skin as to be scarcely observable. The specimens in succession are as follows: 1, the round eggs; 2, the eggs elongated; 3, larva with head, tail and branchiæ distinguishable; 4–6, the same, showing successive stages of diminishing branchiæ, with body and head much altered, and with gill covers appearing; 7, 8, the same, showing the progression of the posterior legs; 9, the same, with the anterior legs appearing; 10, the same more fully developed; 11, the young frog with the tail nearly absorbed; 12, 13, fully developed frogs."

Meeting of November 16th, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Twenty-seven persons present.

Dr. T. O. Summers and Mr. A. J. C. Anderson were elected resident members of the Society.

The following persons were appointed by the chair as Committee on Annual Exhibition: George William Kosmak, Thomas B. Briggs, George H. Blake.

OBJECTS EXHIBITED.

1. Segmented eggs of *Amphioxus lanceolatus*, 4-cell stage: by G. W. KOSMAK.

2. The same, 8-cell stage: by G. W. KOSMAK.

3. The same, 32-cell stage: by G. W. KOSMAK.

4. The same, gastrula stage: by G. W. KOSMAK.

5. Section of nepheline dolerite: by CHARLES S. SHULTZ.

6. Section of blast-furnace slag, Sheffield, England: by CHARLES S. SHULTZ.

7. Section of pikrite, Scotland: by CHARLES S. SHULTZ.

8. Parts of embryo cat, preserved in formaldehyd: by L. RIEDERER.

9. Embryos of the southern lizard, *Anolis*, preserved in formaldehyd: by L. RIEDERER.

Mr. Kosmak illustrated his exhibits by the use of blackboard drawings; stated that the eggs were brought from the Straits of Messina by Prof. Wilson, and that Prof. Whitman and Johns Hopkins University had some of the same, there probably being no others in this country; explained the segmentation and the peculiarities of the structure; and gave some notice of the observers of the development.

Mr. Riederer spoke of the excellent preservative properties of formaldehyd for anatomical specimens, and explained that the embryos of *Anolis* were reared by himself.

Mr. Kosmak remarked that these embryos were rare and interesting; referred to the puncturing of the egg shell by the chick, and the presence of the premaxillary tooth in the snake and the alligator, drawing a line and aiding in the splitting of the shell; and stated that it would be a great satisfaction to know if this tooth exists in the case of *Anolis*.

MEETING OF DECEMBER 7TH, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Fifty persons present.

Mr. Reginald C. Woodcock was elected a resident member of the Society.

The following persons were appointed by the chair as Committee on Nominations of Officers: F. W. Devoe, William G. De Witt, Walter H. Mead, William E. Damon, F. W. Leggett.

Dr. T. O. Summers read a paper, entitled "Pronuclein, the Phagocytoblast of the Organism." This paper was illustrated by microscopical mounts as noted below, and was discussed by Prof. Schweitzer, Dr. Seld and Mr. Kato. The thanks of the Society were tendered Dr. Summers for the presentation of this paper.

OBJECTS EXHIBITED.

1. Pure nuclein.
2. The same acted on by the blood.
3. The same prepared in sugar.
4. The same mixed with blood corpuscles.

Exhibits Nos. 1–4, by T. O. SUMMERS.

5. Hydroid, *Eudendrium*: by G. W. KOSMAK.
6. Hydroid, *Pennaria*: by G. W. KOSMAK.

Mr. Kosmak explained his exhibits, referring especially to the digestive functions of *Hydra*.

MEETING OF DECEMBER 21ST, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Twenty-nine persons present.

Dr. Henry S. Hathaway and Dr. H. A. Parmentier were elected resident members of the Society.

Mr. Walter H. Mead reported for the Committee on Revision of the By-laws, proposing certain amendments.

On motion the report was accepted and adopted, and the Committee was discharged.

Mr. Mead also reported for the Committee on Nominations of Officers the following nominations for the year 1895: President, Edw. G. Love; Vice-President, Frank D. Skeel; Recording Secretary, George E. Ashby; Corresponding Secretary, J. L. Zabriskie; Treasurer, James Walker; Librarian,

L. Riederer; Curator, George E. Ashby; Auditors, F. W. Devoe, F. W. Leggett, E. A. Schultze.

The Corresponding Secretary read a communication from Mr. K. M. Cunningham, of Mobile, Alabama, describing a new diatom. This communication was accompanied by a donation to the cabinet of the Society of a specimen of the radiolarian chalk, and a prepared slide and drawing of the diatom, to all of which reference was made.

OBJECTS EXHIBITED.

1. *Alcyonium palmatum*, mounted entire: by G. W. Kosmak.

2. The same, transverse and longitudinal sections: by G. W. Kosmak.

3. *Branchippus stagnalis*, living: by A. D. Balen.

4. Photomicrograph of a leak in a glycerine mount: by E. G. Love.

Mr. Balen remarked that *Branchippus* appears late in the Fall, being found in water coated with ice, under which conditions it will flourish until Spring and then disappear. He had never found it later in the Spring than the month of March. The eggs fall to the bottom of the water, where they remain during the Summer. Like the eggs of *Hydra* they are well furnished with spines.

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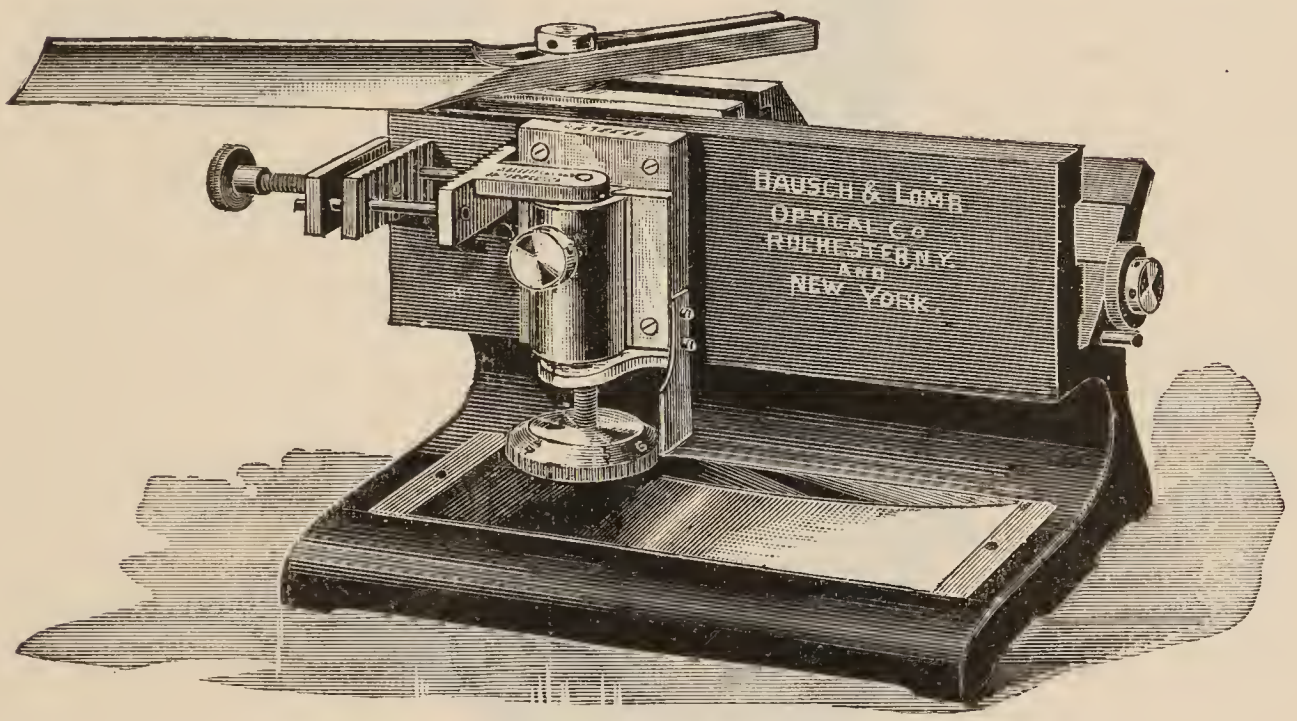

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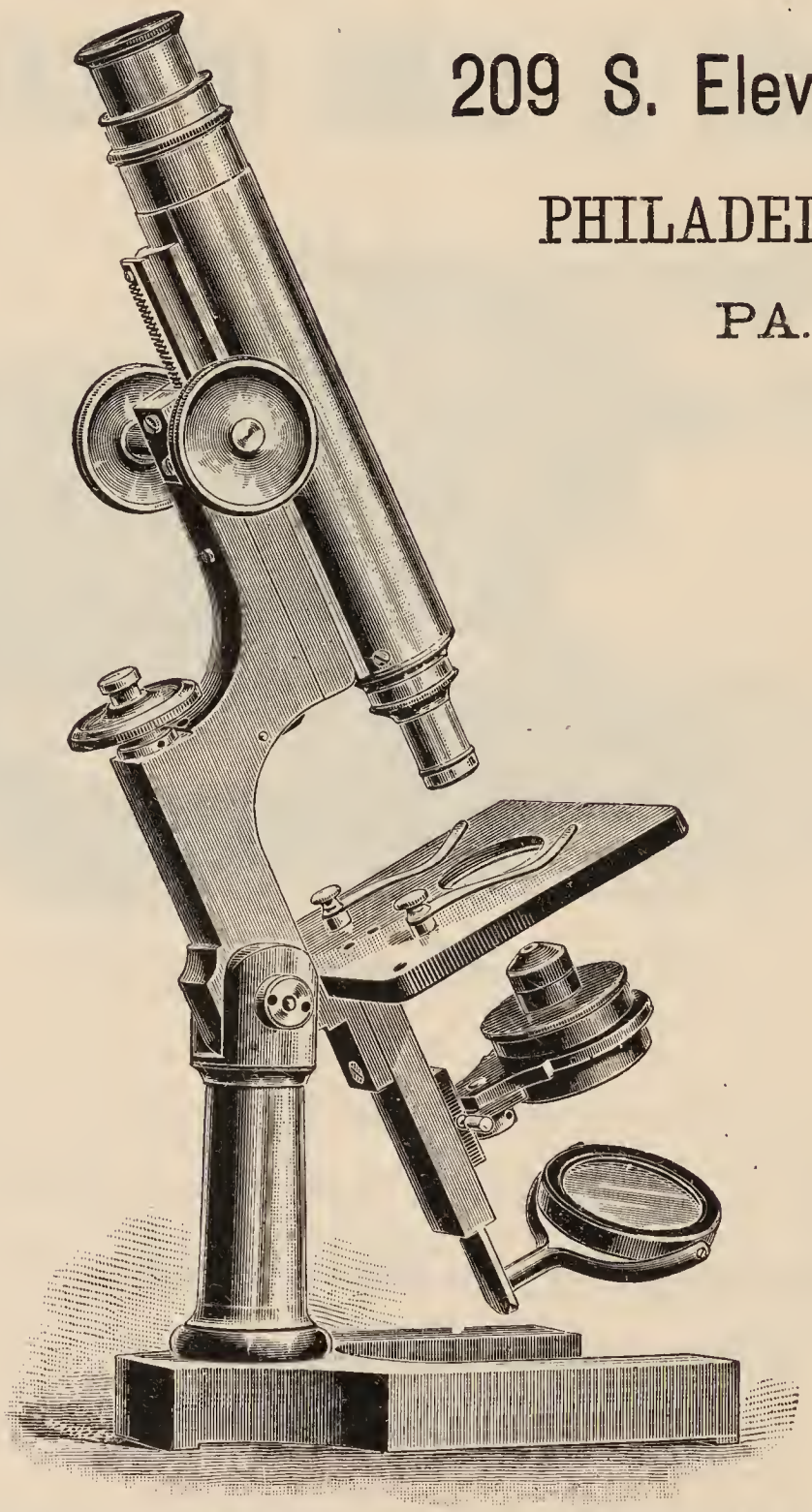

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